

ANALYSIS OF THE LANDING SHIP TANK (LST) AND ITS INFLUENCE ON
AMPHIBIOUS WARFARE DURING WORLD WAR TWO

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fulfillment of the requirements for the
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Military History

by

BRANDON C. MONTANYE, LCDR, USN
B.S., Iowa State University, Ames, Iowa, 1997

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Name of Candidate: LCDR Brandon C. Montanye

Thesis Title: Analysis of the Landing Ship Tank (LST) and its influence on
Amphibious Warfare during World War Two

Approved by:

_____, Thesis Committee Chair
John T. Kuehn, Ph.D.

_____, Member
Richard T. Anderson, M.S.

_____, Member
Robert M. Brown, M.S.

Accepted this 13th day of December 2013 by:

_____, Director, Graduate Degree Programs
Robert F. Baumann, Ph.D.

The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

ANALYSIS OF THE LANDING SHIP TANK (LST) AND ITS INFLUENCE ON AMPHIBIOUS WARFARE DURING WORLD WAR TWO, by LCDR Brandon C. Montanye, 80 pages.

The creation and implementation of The Landing Ship Tank brought amphibious operations to a new level of significance in the U.S military during WWII. Without its introduction during the war, many operations such as the landing at Normandy or the island hopping of the Pacific, would have been delayed or not conducted and could very well have cost the US victory during these conflicts. Presented in this thesis is a review of amphibious warfare development in the interwar period to include the aspects of doctrine and tactics, types of landing craft and ships that were used by the U.S. Military. It also examined the training exercises and the equipment that were available to the U.S. military in the interwar period. Further, the study conducts an analysis of the technological innovations that were introduced because of the operational requirements for the LST and the way in which they were employed in theater. This thesis looks at the evolution of the LST from its initial conception to the end of WWII in 1945. The study finds that the LST performed a vital service to the U.S. and its Allies during WWII and it changed how the U.S. military conducted amphibious operations on a tactical and operational level. It also shows that the LST did not impact published amphibious warfare doctrine. A historical understanding of this ship and the influence it had on major operations during WWII can provide insight for future naval leaders and policy makers in the design and employment of innovative new amphibious ships.

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A special thanks to Captain Robert Jornlin for taking time to give me a personal tour of *LST-325* and sharing his in-depth knowledge about the LST.

In memory of Captain Lawrence Jack Goddard, USNR (Ret), Commanding Officer, *LST-225*.

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CHAPTER 1

INTRODUCTION

The creation and implementation of The Landing Ship Tank (LST) brought amphibious operations to a new level of significance in the U.S military during WWII. Without its introduction during the war, many operations such as the landings at Sicily, Normandy, and Iwo Jima would not have occurred as early as they did, leading to war termination in 1945, and could very well have cost the US victory during those conflicts. A historical understanding of this ship and the influence it had on major operations during WWII can provide insight for future naval leaders and policy makers in the design and employment of innovative new amphibious ships.

The primary question this thesis will answer is what, if any, influence did the invention, development, acquisition, and deployment of the LST have on amphibious warfare doctrinally, operationally, tactically and technologically for the U.S. Military in WWII? With the budget restraints and austerity that the military can expect to see in the future along with efforts to maintain a strong amphibious force, a historical study of what made the LST a versatile and successful platform for amphibious warfare warrants research.

Background

During the interwar period (1918-1939), the United States military recognized the need to develop amphibious warfare doctrine. Headed by the United States Marine Corps (USMC), doctrine was developed from the mid-1920s through the 1930s. However, little attention was given to the development of a dedicated ocean going amphibious transport

ship. Instead modifications were made to existing ships and equipment already in use.

The United States Navy did not see a need to invest in an amphibious fleet since ships of this type were considered auxiliary and not offensive combat ships.¹

However, in planning for combat operations on mainland Europe, the British recognized the need for an increased amphibious force, specifically a type of ship capable of transporting large numbers of heavy tanks, artillery and personnel directly to the beach. Out of this necessity the concept for the Landing Ship Tank (LST) was conceived. Due to an already burdened ship building industry, Britain did not have the capabilities to produce the number of LSTs it required.² Under the Lend-Lease program, the largest numbers of LSTs would be produced for Britain in the United States. The U.S. Navy Bureau of Ships drew up the concept plans based on an already existing converted flat bottom ship used as an oil tanker in the Gulf of Maracaihos in Venezuela.³ After some debate within the U.S. Military about a purpose and its specifications for this type of ship, it was accepted by the British and adopted by the U.S. Navy. In 1942, the U.S. commissioned the first LST. The LST's length was 326 feet long with a beam of 50 feet.

¹Allan R. Millet, "Assault from the Sea," in *Military Innovations in the Interwar Period*, eds. Williamson Murray and Allan R. Millett (New York: Cambridge University Press, 2009), 83.

²Norman Friedman, *U.S. Amphibious Ships and Craft* (Annapolis, MD: Naval Institute Press, 2002), 117.

³J. D. Ladd, *Assault From the Sea 1939-45* (New York: Hippocrene Books, 1976), 200.

It was an ocean-going equivalent of smaller landing craft that had been used prior to 1942.⁴

Several new technologies and concepts were used in designing this type of ship; for example the LST was designed with a flat bottom hull, which gave a ship this size a unique capability to put troops and equipment directly on the beach. This brought the advantage of eliminating the need for prepared docking facilities or the requirement for cranes to unload cargo from the ship. In addition, a new design of ballast pumps and tanks made it possible to give the ship a shallower draft to assist in placing the ship directly on the beach. This capability provided the advantage of assaulting or landing at locations that were not well defended. This eliminated the need to seize heavily defended sea ports. The bow was made up of two large doors that would open to allow a ramp to be lowered for the deployment of troops and equipment. This uniquely designed ship would be used in both theaters of operation during WWII by U.S. and its allies for all major amphibious landings.⁵

Primary Research Question

What changes were made, if any, to the way the U.S. conducted amphibious operations because of the LST? What technological innovations were introduced because of the requirement for the LST? How did Amphibious Doctrine change, if at all, once the LST was placed in operation?

⁴Great Britain, *Landing Ship Tank: Description & Operational Employment: 1944* (London, UK: War Office, 1944).

⁵Ibid. 5-7.

Secondary Research Questions

1. What design modifications were made to the ships for their use in different theaters of operation?
2. How did the building of these ships effect the production of other types of vessels used by the U.S.?
3. How did the U.S. Army and USMC differ in their utilization of the LST?
4. What other types of missions did the LST perform other than amphibious assaults and was their doctrine or tactics associated with those missions?

The above questions will try to determine if the LST changed the way the U.S. military conducted amphibious operations on a doctrinal, operational and tactical level during WWII.

Significance

The creation and implementation of The Landing Ship Tank (LST) brought amphibious operations to a new level of significance in the U.S military during WWII. Without its introduction during the war, many operations such as the landings at Sicily, Normandy, and Iwo Jima would not have been possible and could very well have cost the US victory during those conflicts. A historical understanding of this ship and the influence it had on major operations during WWII can provide insight for future naval leaders and policy makers in the design and employment of innovative new amphibious ships.

Assumptions

This study assumes that all tactics and doctrine for amphibious operations prior to 1942 were written for smaller vessels rather than a sea-going ship that would beach itself and land heavy equipment and sizable tactical units of personnel.

Limitations

The ship was used primarily by the British, Canadian and U.S. militaries during WWII, this study will confine itself to the use of the LST by the U.S. Military and the operations that it was involved with until the end of WWII in both the Pacific and Atlantic theaters. Additionally, the analysis of amphibious warfare doctrine and tactics in the interwar period will also be confined to the U.S. Military.

Delimitations

This thesis will not address the LSTs designed and built after 1945, their use by the military, or the doctrine and tactics used in amphibious warfare after 1945.

Methodology

This thesis is a detailed look at how the LST was designed, developed and employed during WWII by the U.S. military. It will provide insight into how amphibious warfare was conducted prior to and during WWII. This study will entail a comparison between amphibious operations, doctrine, tactics and technology during the interwar period (1918-1939) and WWII with the invention of the LST. This comparison will be based upon the training exercises, international treaties and the equipment that was available to the U.S. military during the interwar period. This aspect of the study will assess the capabilities and limitations of the U.S. amphibious force prior to 1942, when

the LST was brought into service. It includes a discussion of the U.S. ship building capabilities during the war. Furthermore, the study will show how the U.S. utilized the LST differently than the landing craft and equipment used prior to 1942 and the adaptations that were made to the LST to perform in different theaters of operation for various missions. The study will also look at the impact LSTs had on major amphibious landings throughout the war. In conclusion, it will be determined if the LSTs employment during the war changed how the U.S. conducted amphibious operations.

Literature Review

Numerous books and other records are readily available to analyze the LST and the changes that it brought to amphibious warfare during World War II. The actual operation of the ship will be covered by a small number of primary sources, as well as the tactics used for its employment. A key source on the history and use of the LST is Norman Friedman's *U.S. Amphibious Ships and Craft* 2002.⁶ Friedman covers a wide range of amphibious ships and explains the differing views and contributions of the U.S. military as well as the British, and how they affected the development of the LST. He explains the production process of the LST and the way in which different industries changed to accommodate the building of the LST. He also incorporates the many variants of LST that were developed during WWII. The majority of the information he presents comes from archival primary sources.

The relationships between amphibious doctrine, tactics and the ships design will be key in analyzing how the LST was employed in the different theaters of operations

⁶Friedman.

and how it impacted the way amphibious warfare was conducted. Accordingly this information will come from primary sources, principally *Combined Operations Pamphlet No. 18, Landing Ship Tank: Description and Operational Employment*.⁷ This operational instruction doctrine gives a unique detail on how the crew of an LST planned for and operated the ship during amphibious landings as well as technical data concerning the ship. U.S. Navy Training Films “The LST Description,” “Beaching the L.S.T.” and “The LST Employment” show the interworking of the ship and exactly how the ship was operated at sea and how the LST conducted beaching operations as well as technical data about the ship.⁸ The War Department Field Manual (FM 31-5) *Landing Operations on Hostile shores* describes the functions of the Army and Marine Corps in conducting amphibious landing operations on enemy beach heads.⁹ *ONI 226-Allied Landing Craft and Ships*.¹⁰ This source will provide data on the different characteristics of the different variants of LSTs that were used during WWII and the different types of landing craft that were used in conjunction with the LST for amphibious landings. The *Proceedings and Hearings of the General Board of the U.S. Navy 1900-1950*¹¹ provides insight on how

⁷Great Britain, *Landing Ship Tank*.

⁸*The LST Description* (MN-4302a), United States Navy Training Film, 1944; *Beaching the L.S.T.* (MN-942ab), United States Navy Training Film, 1944; *The LST Employment* (MN-4302a), United States Navy Training Film, 1944.

⁹War Department, War Department Field Manual 31-5, *Landing Operations on Hostile Shores* (Washington, DC: War Department, 1944).

¹⁰Navy Department, *ONI 226-Allied Landing Craft and Ships* (Washington, DC: Navy Department, 1944).

¹¹Proceedings and Hearing of the General Board of the U.S. Navy 1900-1950, Record Group 80, text-fiche, Combined Arms Research Library, Fort Leavenworth, KS.

much importance was placed on amphibious warfare and the building of LSTs by the U.S. Navy. *Conference on Landing Assaults 24 May-23 June, 1943 Vol I and II*¹² provides planning information on how the LST would be utilized during amphibious combat operation for the Normandy invasion. The numerous memoirs, biographical and autobiographical works that have been written since the end of WWII will provide an insight on the interworking's of the LST on a day to day basis as well as how they were operated during combat operations by their crews. Secondary sources will provide technical data, combat operations that LSTs were involved in and the different ways the ships were used outside of their primary role of putting troops and vehicles on the beach. They will also provide a background on amphibious warfare development in the interwar periods which lead up to the development of the LST.

Norman Friedman's. *U.S. Amphibious Ships and Craft*¹³ and J.D. Ladd's *Assault From the Sea 1939-45*¹⁴ will provide technical data for the different variants of LST throughout WWII and how they were employed in different theaters of operations. They also together the British development of the LST and how it influenced the development of the LST. Ladd's book also explains how assault forces were created and the procedures that they used with regards to the different types of landing craft and assault ships that were used during operations in WWII.

¹²Commanding Officer Assault Training Center European Theater of Operations, "Conference on Landing Assaults 24 May-23 June 1943," Vol 1: U.S. Assault Training Center European Theater of Operations, U.S. Army, 1943.

¹³Friedman.

¹⁴Ladd.

Williamson Murray and Allan R. Millet's *Military Innovation in the Interwar Periods*¹⁵ highlights the development of amphibious warfare and the different types of ships that were used between the major world powers during the interwar period. This book gives an insight into how the U.S. was developing its amphibious doctrine, tactics and landing craft in comparison to the other world powers. It also connects the development of the LST to the concepts and theories the British were utilizing. William L. McGee's *The Amphibians are Coming*,¹⁶ examines the landing craft of the interwar period and how they were developed into the amphibious force of WWII. He also writes about where these amphibious forces were employed in both theaters of operation. His writing contains several personal accounts from crewmembers of the different types of craft and ships that were used for invasion in the Pacific and Atlantic theaters of operation.

David C. Emmel's *The Development of Amphibious Doctrine*¹⁷ provides in depth information about the interwar period and how amphibious doctrine evolved into the incorporating of operational concepts, tactics, and the required equipment and landing craft for an amphibious force. He explains the evolutionary development of amphibious doctrine between the different branches of the U.S. Military and how they employed that that doctrine during World War II.

¹⁵Williamson Murray and Allan R. Millett, *Military Innovation in the Interwar Period* (New York: Cambridge University Press, 1996).

¹⁶William McGee, *The Amphibians are Coming! Emergence of the 'Gator Navy and its Revolutionary Landing Craft*, vol 1 (Santa Barbra, CA: BMC Publications, 2000).

¹⁷David Emmel, "The Development of Amphibious Doctrine" (Master's Thesis, U.S. Army Command and General Staff College, 2010).

Research Design

The primary question this thesis will answer is, what changes were made, if any, to the way the U.S. conducted amphibious operations because of the LST? What technological innovations were introduced because of the requirement for the LST? How did Amphibious Doctrine change, if at all, once the LST was placed in operation?

The study will review amphibious warfare in the interwar period to include the aspects of doctrine and tactics, types of landing craft and ships that were used by the U.S. Military. It will also examine the training exercises, international treaties and the equipment that were available to the U.S. military in the interwar period. This aspect of the study will assess the capabilities and limitations of the U.S. amphibious force prior to 1942, when the LST was brought into service. It will answer the question of what changes were made, if any, to the way the U.S. conducted amphibious operations because of the introduction of the LST.

Further, the study will conduct an analysis of the technological innovations that were introduced because of the operational requirements for the LST and the way in which they were employed in theater. It will also look at the progression of the design of the LST from its initial conception to the end of WWII in 1945 and how it evolved over the three year span. These design modifications will be viewed as to how the LST was utilized for various types of missions throughout both the Pacific and Atlantic theaters of operation.

The thesis consists of five chapters. The second chapter explains amphibious warfare in the interwar period to include the aspects of doctrine and tactics, types of landing craft and ships that were utilized prior to the introduction of the LST. Chapter

three will review the technological developments that were required to build the LST and its capability of being an ocean going amphibious platform. Chapter four will review the capabilities that the LST brought to amphibious warfare and how they were employed during WWII to include any modifications that were made to the LST from 1942 to 1945 as well as impact at the operational level of war. Chapter 5 provides the conclusions and discussion of further research considerations.

CHAPTER 2

BEFORE THE LST: AMPHIBIOUS WARFARE DURING THE INTERWAR PERIOD

During the interwar period, the United States Marine Corps and Navy headed the development of amphibious doctrine, tactics and equipment. This was a task that seemed simple, but proved to be very complex on several different levels operationally and tactically. The Navy and Marine Corps, even though they were competing for military resources due to fiscal restraints, worked together to develop written doctrine and a practical landing craft based on their experience through Fleet Exercises.

One of the initial steps in developing amphibious doctrine, tactics and equipment was the Navy's publication of the *Landing-Force Manual, United States Navy* in 1920 and updating it regularly until 1938. Its primary subject matter was drill, ground tactics, and combat principles. A very limited portion of the manual, approximately seven pages out of the total seven hundred sixty, dealt with ship to shore operations. The *Landing Force Manual* was also limited in how it described the type of vessel that would be used for the landing; it simply used the nomenclature "boat," referring to the ships' boats they kept onboard. The boats would form up and be towed in by a lead boat that was either steam or motor powered (Appendix A Figure 1). At the time, ship to shore movements were not considered an offensive tactic. The manual emphasized selecting an undefended beach to conduct a landing. If the enemy covered the beach with effective artillery fire that could not be neutralized, the manual directed, "it will usually be better to change the place of landing and attempt to capture the position by a flanking movement."¹⁸

¹⁸U.S. Navy Department, *Landing-Force Manual: United States Navy, 1927* (Washington, DC: Government Printing Office, 1921).

Early in the interwar period, the U.S. recognized that Japan was a potential enemy and that if attacked, the U.S. would have to launch a counter offensive across the expanse of the Pacific. Following an initial study by the Office of Naval Intelligence on an *Overseas Naval Campaign*,¹⁹ in 1921 Marine Corps Major Earl “Pete” Ellis published “Advanced Base Operations in Micronesia.” His paper outlined how offensive amphibious operations should be conducted. He stressed that the rapid deployment of troops from ship to shore was essential. In February 1924, the Navy and Marine Corps tested those theories during “Fleet Problem Number IV” (FP IV) which was an exercise that landed 1,700 Marines on Culebra Island in Puerto Rico.²⁰ It was a first of many Fleet Landing Exercises throughout the interwar period that exposed the problem of troop and equipment movement to the shore with existing landing craft.

FP IV was the jumping off point for the USMC and USN to begin to consider the idea of a dedicated landing craft more seriously rather than simply using the standard ships’ boats.²¹ These boats were basic whale boats and Navy launches, made of wood and had a rounded bottom to their hull. They had been the accepted means since the days of John Paul Jones for ferrying troops ashore. Limited in their carrying capacity, they often ran aground off the beach, causing the assault force to have to wade through water chest deep just to get to the beach. These boats were not suitable for the rapid landings of large

¹⁹John T. Kuehn, *Agents of Innovation: The General Board and the Design of the Fleet That Defeated the Japanese Navy* (Annapolis, MD: Naval Institute Press, 2008), 130-131.

²⁰John A. Lorelli, *To Foreign Shores: U.S. Amphibious Operations in WWII* (Annapolis, MD: Naval Institute Press, 1995), 9-18.

²¹Kenneth J. Clifford, *Amphibious Warfare Development in Britain and America from 1920-1940* (Laurans, NY: Edgwood, 1983), 87.

numbers of troops and their equipment. In 1925, the Commander-in-Chief of the U.S. Fleet, Rear Admiral Robert Coontz made the statement:

use of regular ships' boats for . . . transporting landing parties ashore, when opposition is to be encountered, is a hazardous undertaking and little likely to succeed . . . it[is] of the utmost importance that experiments be continued...to determine what type of boat is best . . . a landing operation is likely to [be a] disaster if the officers in charge of the boats are not experienced.²²

By making this statement, he recognized that in order to have a successful landing operation that a new type of boat or craft and its crews required a continuation of their development.

Thus, it was widely acknowledged that a more suitable craft was needed for ship to shore movement of troops. In an April 1931 *United States Naval Institute Proceedings* article Major Harold H. Utley, USMC, argued that special boats for landing operations were required. He stated, "At the present time there appears to be no adequate supply of suitable boats, nor any generally accepted doctrine based on experience or experiment as to just what characteristics such boats should possess."²³ Prior to this several different types of boats had been tested. Some were prototypes and others were boats that had been converted from already existing hull types.²⁴

One of the boats which the Navy and Marine Corps tested was the "Beetle Boat" designated "Troop Barge A."²⁵ This type of boat was used by the British at Suvla Bay in

²²Lorelli, 12.

²³Harold H. Utley, "Special Boats for Landing Operations," *U.S. Naval Institute Proceedings* 57, no. 4 (April 1931): 520.

²⁴Timothy Moy, *War Machines: Transforming Technologies in the U.S. Military, 1920-1940* (College Station, TX: Texas A&M University Press, 2001).

²⁵Clifford, 88.

the Gallipoli campaign and in 1925 by the Spanish at Alhucemas in Morocco. It was fifty feet long, armored against rifle, machine gun, and shrapnel fire, it carried about 160 men and had a speed of approximately five knots.²⁶ It was built of steel and weighed forty six thousand pounds. Air tanks were built into the hull to increase buoyance. The boat was encased in a metal shell for protection. Troops would disembark via a large bow hatch (Appendix A Figure 2). They performed well in smooth water, but did not handle very well in rough seas.²⁷ These boats' initial service test was at Fleet Problem Number IV.

Brigadier General Eli K. Cole was in command of the expeditionary force for the exercise and he evaluated the boats performance:

This is a beginning, but the present design must be altered, if for no other reason than that its stowage on board ship reduces the motor sailors by two-i.e. one 50 ft and one 40 ft, with landing capacity of 160 men. Some design must be arrived at whereby a transport can carry boats for at least 60 percent of the infantry force on board, with special provisions for artillery, transportation, supplies, etc. These boats should be seaworthy enough to allow them to go 20 miles under their own power, and if possible of a design to permit their being towed by a minesweeper or a destroyer at reduced speed. A design which will give protection against machine gun fire and which provides for some machine gun fire from the boat is desirable.²⁸

Recognizing these draw backs for the Beetle Boats, a fifty foot motored lighter was designed and built. It was called the Type "A" boat. These boats were armored to withstand small arms and machine gun fire. It also had an armored canopy that could be removed to utilize the boat as a cargo carrier. When the boat was fully loaded it could reach speeds of eight knots and had a draft of two and a half feet. Empty it weighed

²⁶Utley, 520-521.

²⁷Moy, 120.

²⁸Clifford, 88.

39,000 pounds. Other smaller less armored variants of the Type “A” were designed and built called the Type “B” and “C”. The issue of troop disembarkation remained because troops had to jump out of a hatch into shallow water or onto the beach. The size and speed of the boats posed an issue because they were viewed as an easy target that carried over a hundred troops.²⁹ Although these boats were not the solution to the problem of effectively transporting troops and equipment from ship to shore, they were more steps in the right direction.

More progress came in 1933. The Marine Corps formed the Equipment Board. The Board’s main focus was to evaluate equipment for use by troops in amphibious warfare. They worked with the Navy and Army in testing the equipment. The Board was the first of its kind to be devoted entirely to amphibious warfare equipment. The procurement of a suitable landing craft was one of the tasks of the Board.³⁰ There were three types of landing craft that the board wanted to evaluate. The first were “landing boats”, these were used to carry troops from the ship to the shore. The second were “lighters,” these were used to carry tanks and trucks. The third were “amphibians,” which were a fire support weapon, and could be considered amphibious tanks.³¹

In 1935, the Navy and Marine Corps investigated commercial small boat manufacturers for a suitable “landing boat”. The Navy’s Bureau of Construction and Repair (BuCon), later to be renamed Bureau of Ships in 1940, requested bids from

²⁹Utley, 520.

³⁰Robert D. Heinl, “The U.S. Marine Corps: Author of Modern Amphibious Warfare,” in *Assault from the Sea*, ed. Merrill L. Bartlett (Annapolis, MD: Naval Institute Press, 1989), 188.

³¹Clifford, 109.

boatyards to build a prototype landing boat. By November of 1935, eleven builders had placed their bids. The requirements that BuCon gave the builders included: the boat had to carry eighteen men, be sea worthy in heavy weather, measure no more than thirty feet long and weigh less than ten thousand pounds, run at fifteen knots in the open sea, have a draft “as shallow as practicable,” have the ability to land through surf in anything less than storm conditions and remain upright when grounded and then “get off the beach under its own power.”³²

Out of the eleven bids that were placed, only five would be selected to participate in testing at Cape May, New Jersey the following summer in 1936. They came from small boat companies from New York, New Jersey and Maine. Four of the five boats tested were modified fishing boats. Three of these boats were tested again in May of 1938. They were still not satisfactory for their intended use.³³ In the winter of 1938, they were operationally tested during the Fleet Exercises, again at Culebra, Puerto Rico. They did not perform well:

The modified fishing craft still had serious drawbacks to their exposed rudders and propellers they tended to dig in when retracting. They were so high forward that Marines debarking had to drop 10 feet from the bow to the beach. They were, moreover, all unsuitable for lowering and hoisting.³⁴

With the information the Board had gained from the commercial manufacturers, they pushed the Navy to buy and develop suitable landing craft. In January of 1937, the Secretary of the Navy established the “Department Continuing Board for the

³²Moy, 140.

³³Ibid., 143.

³⁴Clifford, 110.

Development of Landing Boats and Training Operations.”³⁵ The Board reviewed concepts for landing craft and how they should be employed during amphibious operations. As a result of this process one of first real successful landing craft, the Higgins Boat was revealed.

Andrew J. Higgins had developed a shallow draft vessel designed for use in the bayous of Louisiana by fur trappers and oil drilling operators. It had the ability to beach and retract with ease and it had a protected propeller; features that made it the ideal landing craft. Because it had a rounded bow, the problem still existed that there was not an easy way to disembark troops; they had to climb over the sides. In order to solve this problem Higgins installed a ramp to replace the rounded bow. These boats were named “Eurekas.”³⁶ (Appendix A Figure 3)

There were three variants of the Eureka boat. With each of them the installation of a ramp in place of the rounded bow, it allowed the boats to be able to disembark troops directly to the beach. It also gave it the capability to transport trucks and light tanks to the beach. They were designated as LCP(L) or Landing Craft Personnel (Large). It was 36 feet long and had the capacity for up to 36 troops or 6,700-1,800 pounds of cargo and had two .30 caliber machine guns. LCVP - Landing Craft, Vehicle Personnel had the capacity to carry 36 troops, or 6,000 pound vehicle or 8,100 pounds of cargo. The LCM Landing Craft Mechanized had the capability to carry single tank weighing from 13 ½ tons to 30

³⁵Lorelli, 16.

³⁶McGee, *The Amphibians are Coming!*, 32-33.

tons. Higgins Company was able to produce any type of boat that the amphibious force needed.³⁷

Through the Fleet Exercises, work the different Boards had conducted, and the more focused study the Marine Corps School at Quantico was taking towards amphibious warfare, the Marine Corps developed and published the *Tentative Landing Operations Manual* in 1934. The *Tentative Landing Operations Manual* is entirely dedicated to landing operations. The chapter that covers ship to shore movements describes the evolution: “the movement is more than a simple ferrying operation and involves much of the tactics of fire and movement.”³⁸ This was a paradigm shift from the 1920 manual that the Navy had published. Although the manual was still “tentative,” it was tested and improved through the continued use of the Fleet Exercises that were held each winter from 1935 through 1941.

The *Tentative Landing Operations Manual* was formally adopted by the Navy in 1938 and entitled Fleet Training Publication Number 167 (FTP-167) *Landing Operations Doctrine, U.S. Navy*. It would later be adopted by the U.S. Army in June of 1941 as FM 31-5 *Landing Operations on Hostile Shores*. The FM 31-5 was virtually unchanged from the FTP-167.³⁹ These manuals even focus on the design of the landing boats. This was a driving force for the development of better landing craft for amphibious operations during the late 1930’s.

³⁷Navy Department, *ONI 226-Allied Landing Craft and Ships*.

³⁸United States Navy, U.S. Navy F.T.P. 167, *Landing Operations Doctrine* (Washington, DC: Government Printing Office, 1938).

³⁹Bartlett, 189.

However, the U.S. was still lacking a sea-going amphibious transport ship. All amphibious transportation were conducted with old battleships and fast attack transport ships (APDs), which were converted destroyers and already existing cargo ships that would crane off landing craft into the water while they were anchored off the coast.⁴⁰

NTP-167 addresses this:

The transportation of the required number of boats to the theater of operations is a serious problem. The stowage requirements for boats and other deck cargo may be so large that unusual methods of boat stowage may be imperative. Such conditions may require stowage in holds or tween deck compartments, or construction of platforms or stages designed to increase the available deck stowage space. Some situations may permit the larger boats and lighters to be towed to the landing area. Specially converted ships to act as boat carriers may be necessary in large operations.

The Continuing Board for the Development of Landing Boats and Training Operations recognized the issue associated with the transport of a large amphibious force. The danger was in disclosing the presents of the force by having large transports stop at sea, several miles from the shore to disembark landing craft and troops. (Appendix A Figure 4) The idea of having a ship with stern ramps to quickly launch lighters with artillery, tanks and troops was proposed. It was viewed as better than relying on the slow cranes of the ships and their booms.⁴¹ This concept was also in line with Ellis's thinking about tactical deployment of the landing force. He thought that the force should be loaded and organized prior to leaving port. He also believed that the transfer of troops and equipment at sea was counterproductive and not practical.⁴²

⁴⁰Millet, "Assault from the Sea," 76.

⁴¹Letter from Captain J. G. Ware to Chief of Naval Operations, Subject: Equipment for Amphibious Operations, 21 June 1940, National Archives Collection.

⁴²Lorelli, 11.

The United States was not the only Allied country searching for a solution to the movement of troops and equipment from ship to shore. Prior to 1939, the British had developed the Mobile Naval Base Defense Organization (MNBDO). It consisted of a detachment of British Royal Marines and their equipment. Their mission was to be established at an overseas naval base within 48 hours to provide basic defense. The MNBDO had established their own requirements for equipment needed to conduct ship to shore movements, such as landing craft.⁴³

The British recognized the need for enhanced amphibious shipping, especially ships that were capable of transporting large numbers of heavy tanks, artillery and personnel directly onto the beach. Out of this necessity the concept for the Landing Ship Tank (LST) was conceived. The concept came from an already existing flat bottom type of ship used as an oil tanker in the Gulf of Maracaibo in Venezuela. The British had converted three of these tankers for amphibious operations, but they proved to be ineffective. Due to an already burdened ship building industry, Britain did not have the capabilities to produce the number of LSTs it required for planned amphibious operations.⁴⁴ Under the Lend-Lease program, it was intended that the largest numbers of LSTs would be produced for Britain in the United States. The U.S. Navy Bureau of Ships drew up the concept plans based on inputs from the British.⁴⁵

⁴³Stephen Roskill, *Naval Policy Between the Wars, Vol. II* (Annapolis, MD. Naval Institute Press, 1976), 258.

⁴⁴Ladd, 200.

⁴⁵*Ibid.*, 205.

Throughout the interwar period the U.S. made progress on developing their amphibious warfare doctrine and despite fiscal restraints, they were also able to develop landing craft, albeit it was not a one hundred percent solution to the problem of rapid deployment of combat troops to the shore, but it was progress. They were also taking advantage of the Fleet Exercises during that period to refine their doctrine and operationally test the landing craft. At the request of the British to design a landing ship, the U.S. found the answer to the rapid movement of combat troops and equipment from ship to shore problem.

CHAPTER 3

THE LST: INITIAL DESIGN, BASIC OPERATION AND PRODUCTION

The United States military had been searching for a solution to the problem of rapid ship to shore movement of combat troops and equipment throughout the interwar period. The British provided the initial concepts for the LST, a ship that would prove to be the amphibious solution for the U.S. The U.S. Navy designed and built the LST in the United States, with the intent of sending the majority of them to Britain under the Lend Lease Program. The design of the ship was innovative, yet simple. It provided solutions to basic problems encountered during amphibious operations. The ships design and its mass production would affect how the U.S. military conducted amphibious operations during the War.

Many of the concepts of how the LST was designed and operated had been used before in other ships, submarines and landing craft. However, the U.S. version of the LST combined all those concepts together to make it the largest beaching type of landing ship built at the time. It was a hard design to improve on in many ways, but very easily adapted.

In September of 1941 at the conclusion of the Landing Exercise at New River, North Carolina, by the Army and Marine Corps, General Holland Smith recommended that a tank carrier be designed with a bow door and a truss bridge that could unload its tanks directly onto the beach. It had to possess the capability of carrying 18 tanks in addition to 18 pre-loaded tank lighters. These recommendations were based on how slow the process took to load one tank landing craft from the transport ship. This was the first

proposal by the United States for a ship like the LST and may have been influenced by the types of craft that the British were using.⁴⁶

The answer to Smith's recommendation was a new type of ship that the British had conceived, but were unable to produce in Britain due to an overburdened wartime ship building industry. The British had requested the U.S. Navy design and build this new type of ship. These ships were originally called Atlantic Tank Landing Craft (ATLC) because they were built in the U.S. and were required to make the trans-Atlantic voyage to Britain.⁴⁷ In November of 1941 the specifications for the ATLCs, later called LSTs, were given to the Assistant Head of the Design Division at the Bureau of Ships (BuShips) Captain Edward Cochrane. He assigned his Civilian Technical Director, John C. Niedermair to come up with a concept drawing using the specifications the British had provided.⁴⁸

The specifications directed that the ship conduct an open ocean voyage, have a speed of ten knots, carry 40 ton tanks, and conduct operations to a beach with a 1:150 slope.⁴⁹ Niedermair sketched out his idea and within a few hours presented it to Cochrane. His design included a flat bottom hull to reduce the draft of the ship. He also included ballast tanks that would be filled for the deeper draft required for open ocean transits. These tanks would also be pumped out to achieve the required draft for beaching

⁴⁶Friedman, 114.

⁴⁷Ladd, 202.

⁴⁸John C. Niedemier. "As I Recall . . . Designing the LST," *U.S. Naval Institute Proceedings* 108, no. 11 (November 1982): 58.

⁴⁹Friedman, 117.

operations. This allowed for beaching on a shore with a slope of 1:50.⁵⁰ Using ballast tanks and pumps was not a common practice with surface ships at the time. Since Neidermair had designed submarines, the idea of a ballast tank system would have seemed obvious to him. The draft forward for beaching operations was 3 feet 6 inches; with a draft that shallow there was no need for a lengthy bow ramp.⁵¹ The draft for ocean conditions was 14 feet 4 inches aft and 8 feet forward, giving the ship a mean draft of 11 feet 2 inches.⁵² Neidermair made a final drawing that night. His plans were approved by BuShips shortly after and then flown to Britain, where they were approved by the Admiralty.

The concepts and design of the LST seemed simple, as shown by Neidermair's quick production of its plans. However, this ship would prove to be a transformative technical innovation for amphibious warfare. The only major changes that were made to Neidermair's initial drawings were that the length of the ship was changed from 280 feet to 328 feet and the beam increased from 45 to 50 feet. It made for an even shallower draft for beaching operations. This was in part due to the increase in plating size for the hull that was originally supposed to be a quarter inch thick, but increased to three-eighths of an inch. One inch thick plating was also used under the bow, specifically for beaching operations.⁵³

⁵⁰Nidermair, 58.

⁵¹Friedman, 118.

⁵²Great Britain, *Landing Ship Tank*, 6.

⁵³Nidermair, 59.

The LST consisted of five decks. One of the elements that made the LST unique was the third deck or “Tank Deck.” It ran most of the internal length of the ship and was 288 feet long and 30feet wide. This was the primary area where vehicles and supplies were carried, it had a volume of 92,765 cubic feet. It was designed for a concentrated load of heavy tanks. The maximum height of a vehicle that could enter the Tank Deck was 11feet 3inches.⁵⁴ The Tank Deck had the capacity to stow twenty Sherman tanks or thirty nine Stuart light tanks, or seventeen Amphibious Tractors (Amtracs).⁵⁵ The ship was designed to stay afloat even if the ship had sustained heavy damage and the Tank Deck was open to the sea.⁵⁶

The vehicles that were stowed in the Tank Deck had to be started ten minutes prior to their disembarkation. Large ventilation fans were installed in the overhead to vent the large amounts of exhaust the vehicles produced.⁵⁷ These ventilation fans were not in the initial design of the ship. Quickly realizing the issue of keeping exhaust fumes out of the Tank Deck, naval architects had a full scale replica of the tank deck built at Fort Knox, Kentucky. Here a large concentration of Army tanks were located for testing. Several operating problems for Tank Deck ventilation were tested and solved at this facility. The final design was to have several exhaust vents installed in the overhead of

⁵⁴Navy Department, *ONI 226-Allied Landing Craft and Ships*.

⁵⁵*The LST Description* (MN-4302a), United States Navy Training Film, 1944.

⁵⁶Bureau of Ships, *LST Special Operations Instruction Book* (Washington, DC: Navy Department, March 1943), 6.

⁵⁷Great Britain, *Landing Ship Tank*, 13.

the tank deck.⁵⁸ The initial build had removable stack type ducting that was spread out over the main deck (Appendix B Figure 5). This limited the amount of cargo and equipment that could be carried. Later built LSTs had the vent ducting moved farther aft in a cluster by the deck house. This opened up the main deck for storage.⁵⁹

The primary means to load and unload the Tank Deck area was one of the best known features of the LST, the bow doors and ramp. The entrance to the Tank Deck was 13feet 3inches wide by 13 feet 7 inches high. While at sea, the entrance was enclosed by the bow ramp and the bow doors. The bow ramp was a drawbridge type ramp and was used for transiting vehicles and cargo to the beach. The ramp was 15 feet 4 inches in width and 23 feet 3inches long. It was raised and lowered with an electric motor and two chains, one on each side of the ramp. (Appendix B Figure 6) The ramp supported 50 tons when it was seated against a 2ft reinforced lip at the bottom of the Tank Deck entrance. It could be lowered to a maximum angle of 23 degrees.⁶⁰ If the beach gradient was greater than 1:50, the bow ramp was not able to reach the beach to offload equipment that was not waterproofed. To resolve this, it was necessary to bridge the water gap between the beach and the bow ramp.

The bow ramp and bow opening were concealed behind two large doors when they were not being employed. The bow doors were clam style doors, meaning that they opened and closed like a clamshell. They created a very blunt shaped bow when closed.

⁵⁸“The LST that Never Went to Sea,” <http://www.knox.army.mil/About/docs/lst.pdf> (accessed 12 August 2013).

⁵⁹Friedman, 121.

⁶⁰Great Britain, *Landing Ship Tank*, 35.

They were secured for ocean going operations with nine turnbuckle dogs on each side of the doors.⁶¹ The door design, along with several other factors, is what limited the speed of the LST to no more than 10 knots. This is what ultimately earned the LST the nickname Large Slow Target. An LST crewmember, Lieutenant James McGuiness observed, “There is no classic lines in her build and her bow is simply a horrible snow-shovel snout that cannot cut the water but pushes the foam ahead of her [sic].”⁶²

The plant that propelled the LST through the water consisted of two General Motors, 12 cylinder, 900 shaft horsepower diesel engines with twin screws.⁶³ The engineering spaces were located on the 4th deck of the ship, aft. They consisted of the Main Engine Room, where the two Main Engines were housed. The Auxiliary Machinery space, this was where the three diesel generators were located, along with the electrical switch boards, the ballast pumps and manifold piping for the ballast and fuel tanks. By designing the ship with all of this equipment aft, it made it more efficient in trimming the ship for a shallower draft forward to conduct beaching operations.⁶⁴

One of the other factors that limited the speed of the LST was its flat bottom hull design. These ships lacked the sleek hull designs of other ships like Destroyers or Battleships. Even ballasted down, flat hulled ships are difficult to handle in rough seas.

⁶¹Robert Jornlin, Interview by author, Onboard LST-325, Charleston, WV, 31 August 2013.

⁶²James L. McGuiness, “The Three Deuces,” *U.S. Naval Institute Proceedings* 72, no. 9 (September 1946): 1157.

⁶³Navy Department, *ONI 226-Allied Landing Craft and Ships*.

⁶⁴Jornlin, Interview.

However, the flat hull design of the LST was the key to obtaining the shallow draft necessary for the ship to conduct beaching operations.⁶⁵

Because the ship went directly onto the beach and the stern of the ship was so close to grounding, a skeg (Appendix B Figure 7) was built on the port and starboard side to house the rudders and propellers. The skegs were also placed closer to center line than originally planned, forming a tunnel. This design prevented the stern anchor that was used to pull the ship off the beach from getting dragged into the tunnel. A design feature that had been used in the *South Dakota* Class Battleships⁶⁶

In order to obtain the draft necessary for ocean going operations as well as beaching operations, the LST had a robust ballast system. The ship had a total of 15 tanks that could be used for ballast. Four of them were dedicated to fuel and the other 11 were used for either potable water tanks or sea water ballast. However, the fuel and sea water ballast tanks were connected via piping so they could be used for either.⁶⁷ The forward ballast tanks would be pumped out in order to trim the ship to the shallower draft forward, while ballasting tanks aft. Once the ship was beached, the forward ballast tanks would be filled to hold the bow firmly on the beach while conducting the offload. In order to retract from the beach, the forward ballast tanks would be pumped out. The ballast and fuel tanks were situated on the port and starboard side of the ship and were located on the 4th deck.⁶⁸

⁶⁵Jornlin, Interview.

⁶⁶Friedman, 121.

⁶⁷Jornlin, Interview.

⁶⁸Bureau of Ships, *LST Special Operations Instruction Book*, 6.

The capability to ballast the ship was accomplished with pumps that were originally designed for submarines. They could pump 1500 gallons per minute of ballast water. If the ship was not able to retract from the beach before low tide and was left “high and dry,” (Appendix B Figure 8) the ballast tanks had the function to be redirected to the main engines and generators for cooling water until the ship was retracted and could return to using sea water suction for cooling.⁶⁹ A feature that would prove invaluable during operations in the Pacific.

For retracting from the beach, the ship was equipped with a stern anchor, a standard Navy Sockless. This was utilized during beaching operations. The anchor was controlled with the stern winch. The winch was equipped with 900ft of cable, but only 600ft of cable was let out for the beaching operations. The stern anchor served two purposes, the first was to assist with the retracting, and the other is to keep the ship straight while beached. It prevented the ship from broaching (the ship becoming grounded parallel to the surf).⁷⁰ Three diesel generators created the power that would be used for the Bow Door, Bow Ramp and Stern Winch motors. Because of the requirement to control the speeds of the electrical motors, all electrical equipment on the ship was operated with Direct Current (DC). The Bow Doors were opened, the Stern Anchor was let go and the Bow Ramp was ready to be lowered 20 minutes prior to the beaching.⁷¹

The initial beaching of the LST was conducted at Quonset Point, Rhode Island in early 1943. The designer of the ship, John Niedemiar was aboard for that testing and

⁶⁹Jornlin, Interview.

⁷⁰Ibid., 7.

⁷¹*Beaching the L.S.T.* (MN-942ab), United States Navy Training Film, 1944.

recommended full speed ahead for a beaching speed, which is approximately 10 knots. He was making a scientific guess when he made that decision, but it became the standard speed for beaching operations.⁷² Beaching operations were not something that was commonly done with ships prior to the LST. As one LST sailor wrote, “It outrages every sense of nautical decency and violates every tenant of seamanship to deliberately send a ship onto shore. It has been done in the past solely as a desperation measure to escape capture or purposefully destroy the ship.”⁷³ With the acceptance of a few, it seems that most of the crews of the LSTs were very junior to the Navy and accepted that beaching was a normal process.

The LST was being built at a very rapid pace. Congress provided the authority to build several types of ships and landing craft, among them was the LST. They did this in three separate acts in February 1942, May 1943 and December 1943.⁷⁴ By 1945 over 1,000 LSTs had been built in the U.S. When the Navy took on the task of building LSTs, the larger ship building yards of the East Coast were used. In July of 1942 BuShips was coordinating the building program and scheduling delivery dates.⁷⁵ The priority of the LST building program increased. So much that the keel of an aircraft carrier that had been laid down in the dock was removed to accommodate several LSTs to be built in her

⁷²Niedermair, 59.

⁷³McGuiness, 1158.

⁷⁴James L. Mooney, ed., “Appendix Tank Landing Ship (LST),” in *Dictionary of American Fighting Ships* (Washington, DC: Government Printing Office, 1981), 570.

⁷⁵Letter from the Chief of the Bureau of Ships, Subject: Conference Concerning the Landing Ship Tank 11 July 1942, National Archives Collection.

place.⁷⁶ The first thirty were built at the Bethlehem Steele yards in Baltimore. They were built and delivered within ten months.⁷⁷ Dravo Shipbuilding Corporation was the lead yard for building. That changed by April of 1944 when the Chicago Bridge and Iron Works took the lead by Gibbs and Cox Inc.⁷⁸

Because of the high demand for the LST, the large shipyards of the East and West Coast were not able to produce the number required. To solve this problem, the Navy employed small boatyards and manufacturing companies on the inland waterways to build the ships. They were located in places such as Evansville and Jefferson Indiana, Seneca Illinois, Ambridge and Pittsburgh Pennsylvania. Between 1942 and 1945, of the 1,051 LSTs built, 670 were constructed by five major inland ship builders. These inland yards were nicknamed “cornfield shipyards.”⁷⁹ The value of the LST was so high, that the date of the Normandy invasion was not set until it was determined that there would be suitable numbers of LSTs built to conduct that operation.⁸⁰ By the end of the War in 1945, the efficiency of these shipyards was apparent when they were building an LST in less than a two month time period.⁸¹ The ships that were built in the Mid-West were

⁷⁶Mooney, 570.

⁷⁷Ladd, 205

⁷⁸Letter from Gibbs and Cox Inc to the Chief of the Bureau of Ships, Subject of Arrangements for Gibbs and Cox to act as design agents for the Chicago Bridge and Iron Company, 17 April 1944, National Archives Collection.

⁷⁹J. Bruce Baumann, *LST 325, Workhorse of the Waves & Evansville War Machine* (Evansville, IN: Evansville Courier and Press, 2005), 41.

⁸⁰Ladd, 205.

⁸¹Baumann, 41.

manned by the permanent crews and then transited down the Mississippi River to New Orleans. The ships were fitted with weapons and any repairs that were required prior to the ships transit to their selected theater of operation.⁸² Although the initial request for the LST ship design came from Britain, only 113 LSTs were transferred to them.⁸³

Because there was a requirement for a ship design like the LST and the British requested the U.S. build it, was the catalyst necessary for the LST program development. The simple concepts that had been used in other, smaller landing craft such as a flat bottom hull and bow ramps, along with ballast pumps were combined. This combination along with the sheer size of the LST gave the military a capability that had not been seen before in amphibious warfare. The ships design along with the U.S. ability to rapidly adapt its industrial infrastructure to produce the number of LSTs to support the war effort helped in its mass production. The LST proved itself to be a very versatile ship. Because of the large amount of space that was available in the Tank Deck as well as on the Main Deck, the LST was used for various mission sets in all theaters of operation that its designer never intended, and the ship was successful at of them.

⁸²Letter from the Commandant, Eighth Naval District to Commanding Officer Naval Station New Orleans concerning LST passage through New Orleans, 16 November 1942, National Archives Collection.

⁸³Mooney, 571.

CHAPTER 4

THE LST: GOING ABOVE AND BEYOND ITS INTENDED USE

The LST was, arguably, the most versatile ship used in World War II. This was due to its simple design, which gave it ample space in the tank deck as well as on the Main deck. This gave the LST an advantage over most ships because it had space to carry just about any type of cargo. It also had the unique capability to transit through the open ocean or to maneuver into shallow waters such as small harbors, rivers and inlets. Because of the ships basic design and characteristics, it was easily modified for any type of mission it was required to do. War correspondent Ernie Pyle described the LST appropriately:

An LST isn't such a glorious ship to look at. It is neither sleek nor fast nor impressively big . . . the engines and crew's quarters and bridges are all aft. The rest of the ship is just a big empty warehouse sort of thing, much like a long, rectangular garage without pillars in it.⁸⁴

Operational experience, along with necessity, led throughout the conflict to the adaption of the LST for employment in both the Atlantic and Pacific theaters. The ease of conversion of the LST made it more valuable than just a ship for rudimentary in theater logistical movements.

The way these ships were employed impacted amphibious warfare at the tactical and operational level. The first time the LST was used in large numbers for combat was Operation HUSKY. This was the codename for a large-scale Allied amphibious and

⁸⁴Norman Palmar and Thomas B. Allen, "The LST," *Military History Quarterly* 4 (Summer 1992): 69.

airborne operation for the invasion of Sicily (July 1943).⁸⁵ This was also the occasion for bridging the gap between the bow ramp and the beach and was operationally tested using pontoon causeways (Appendix B Figure 9), designed by U.S. Navy Captain John N. Laycock. The causeways were subsequently employed in all theaters of operation. In the Pacific theater at Tarawa (November 1943), multiple pontoons were carried by LSTs and used by the Navy Construction Battalion (CB, i.e. “Seabees”) to create jetties and piers alongside the reef.⁸⁶ At Okinawa twenty-nine LSTs transported hundreds of causeways that were used to create piers along the reef. Bridging the gap was done one of two ways, with either causeways or ferries. Causeways were used when the water gap was less than 300 feet; this created a bridge to the beach. An LST had the capability of carrying two causeway units, each being 175 feet long, 14 feet wide. One was attached to each side of the ship and an additional 150 feet long causeway could be attached to the main deck. Unfortunately that limited the amount of cargo the ship could carry. The causeways were modular and could be adjusted to shorter lengths if necessary.⁸⁷

Another type of causeway that was used, was the Landing Craft, Tank Mk 6, also known as LCT (6). The Mark 6 was the sixth version of the LCT, the main difference from the earlier versions of the LCTs was that it had a stern plate that was removable and a gate lowered to moor to the LST. This was done by mooring the LCT and the LST in line. The LCT acted as the causeway when it lowered its bow ramp to marry to the LST

⁸⁵Clifford, 176.

⁸⁶Ladd, 207.

⁸⁷Great Britain, *Landing Ship Tank*, 16.

bow ramp, and remove its stern plates.⁸⁸ Ferrying was the second way that the water gap was bridged. This was accomplished by using LCTs to marry up to the ship's bow ramp and on load vehicles and cargo. The only time this would be done is if the gap exceeded 300 feet or if there was considerable fall or rise in the tides.⁸⁹ This concept is still reflected in modern doctrine with Joint Logistics Over The Shore (JLOTS) operations.⁹⁰

The LST was also unique in that it was a landing ship that carried its own landing craft. Originally it was fitted with two davits to accommodate LCVPs (Landing Craft, Vehicle, Personnel); one on each side of the ship's superstructure. Before the invasion of Sicily, 36 of the LSTs used in that assault were retrofitted with six davits (Appendix B Figure 10). This was because it had been identified that there was a short fall in the number of attack transports available for the invasion. The attack transports were ships that were designed to support amphibious assaults by carrying troops, heavy equipment and supplies. Two additional davits on each side of the superstructure and two on each side of the forecastle were added. These LSTs were used as attack transports. With the extra landing craft, it allowed the landing of an assault element of an infantry company. The extra landing craft were also used as rescue boats, emergency repair boats and control boats for the landing force.⁹¹ It was quickly identified that by adding equipment to the ship, both permanent and removable, that the visibility from the bridge was

⁸⁸Navy Department, *ONI 226-Allied Landing Craft and Ships*.

⁸⁹Great Britain, *Landing Ship Tank*, 19.

⁹⁰U.S. Department of Defense, Joint Publication 4-01.6, *Joint Tactics, Techniques, and Procedures for Joint Logistics Over-the-Shore (JLOTS)* (Washington, DC: Government Printing Office, 1998), ix.

⁹¹Friedman, 122-123.

restricted. In order to remedy the problem a second bridge was easily added. With the addition of the four davits, a conning tower was built on top of the additional bridge for better visibility while conning the ship.⁹²

Similarly, LSTs were first used operationally in the Pacific for logistics. The Spring of 1943 saw delivery of supplies to island outposts. Their initial use in an assault in the Pacific was at Rendova, in the New Georgia Islands of the Solomon Islands, on 30 June 1944, just shortly before HUSKY in the Mediterranean. Even though LSTs were designed for beaching operations, they had the capability to launch Tracked Landing Vehicles (LVT) from the bow ramp while at sea (Appendix B Figure 11). LVTs were more suited for landings in the Pacific because of the coral reefs that typically surrounded the islands. LCVPs would run aground on the reefs before reaching the beach.⁹³ This lesson was learned at places like Tarawa in the Gilbert Islands, during Operation GALVANIC (November 1943). The LCVPs ran aground, leaving the Marine landing force stuck 600 yards off shore on the reef.⁹⁴ By employing the LST this way, it is moved from the tactical to an operational level. This would be considered a WWII variant of the more modern Marine Corps Operational Maneuver From The Sea (OMFTS).⁹⁵

⁹²Friedman, 122.

⁹³Palmar and Allen, 69.

⁹⁴Jerold E. Brown, "Amphibious Operations: Tarawa: The Testing of an Amphibious Doctrine," in *Combined Arms in Battle Since 1939*, ed. Roger J. Spiller (Fort Leavenworth, KS: US Army Command and General Staff College Press, 1992), 23-24.

⁹⁵Lawrence J. Oliver, "Operational Maneuver from the Sea: Realizing a Concept," *The Marine Corps Gazette* (September 2000), <https://www.mca-marines.org/gazette/operational-maneuver-sea-realizing-concept> (accessed 24 November 2013).

Transporting LVTs was not something that could be done by any type of ship. The lifting arms of the troop transport ships were not capable of lifting the LVTs because they were too heavy. The LST was the only landing ship capable of transporting and launching the LVTs. Because of the LSTs shallow draft, they were capable of getting closer to the beach before the LVTs launched. This was an ideal way to launch them because LVTs were slow and there was a decreased distance to the beach, therefore a lesser chance of mechanical break downs were possible or getting hit by enemy gunfire before getting to the beach.⁹⁶ On 15 June 1944 at Saipan on the Mariana Islands, sixty-four LSTs stood off shore when the landings began. While remaining approximately 5,500 yards from shore, LSTs launched almost 700 LVT amphibious tractors loaded with Marines.⁹⁷

One of the modifications that made it possible to carry more LVTs and rapidly deploy them was the Main Deck Ramp. This replaced the main deck to Tank Deck elevator. In order for the elevator to be used, four guide posts had to be put in place in the Tank Deck manually. They had to be removed in order for tank deck vehicles to move out of the bow doors. Due to the size and load capacity of the elevator, LVTs could not be carried on the main deck. The ramp was larger in size compared to the elevator. Unlike the elevator, the ramp required no set up and could be raised and lowered to allow traffic movement within the Tank Deck. It lowered from the main deck at a 40 degree incline to the bow doors (Appendix B Figure 12). This allowed for a more rapid loading

⁹⁶Alfred Dunlop Bailey, "Alligators, Buffaloes, and Bushmasters: The History of the Development of the LVT Through World War II" (Master's thesis, University of Utah, 1976), 86-88.

⁹⁷Palmar and Allen, 69.

and unloading of vehicles from the Main Deck. Because the ramp was larger than the elevator, LVTs could be stowed on the main deck thus increasing the number that could be used in a landing force.⁹⁸ Due to the limited amount of space onboard the LST, they carried the LVTs and their drivers. Troops were transferred via LCVP from troop transports to the LVTs at sea after they launched from the LST.⁹⁹

Another unique modification of the LST was its use as an aircraft carrier. This modification was not led by the Navy, but by the Army. A concept initially developed for HUSKY in order to launch Army L-4 observation planes for artillery spotting. They were not used at Normandy, but they were used on all amphibious landing operations in Mediterranean. These LSTs were nicknamed the “Cub Carriers.” The flight deck, or runway, was orientated centerline on the main deck from the superstructure to the bow (Appendix B Figure 13). The ship was able to accommodate total of ten aircraft; six of which would be stowed on the sides of the flight deck until they were ready to be used.¹⁰⁰ The runway measured 220 feet long by 16feet wide.¹⁰¹ Because the flight deck was too short to land on, as well as the superstructure obstructing the approach end of the runway, the aircraft would land on friendly territory when mission complete. The additional aircraft were launched when the off-going aircraft would be ready to land in order to have constant surveillance of the area. They reported the location of friendly and enemy

⁹⁸*The LST Employment* (MN-4302a), United States Navy Training Film, 1944.

⁹⁹Friedman, 124.

¹⁰⁰Edgar F. Raines, Army Historical Series, *Eyes of Artillery: The Origins of Modern U.S. Army Aviation in World War II* (Washington, DC: Unites States Army Center of Military History, 2000), 221.

¹⁰¹Friedman, 126.

forces, directed naval gunfire on enemy positions and guided landing craft to the beach.¹⁰²

To solve the problem of landing back onto the ship, the Army developed a “Brodie Device,” named after its inventor Army 1st Lieutenant James H. Brodie (Appendix B Figure 14).¹⁰³ This device was used with spotter planes, Marine OY-1s at Iwo Jima and Army L-4s at Okinawa. It was a contraption that consisted of a cable strung between two cargo booms mounted on the Main Deck, one forward on the forecastle and one aft of the superstructure that would catch the aircraft upon landing. Originally it was developed for use on land when an airstrip was not able to be constructed for landing light planes. The cable was stretched over the water on the port side of the ship between the two booms. The aircraft, with a hook attached to the top of it, would catch the cable athwart ship, flying from starboard to port. A winch system would then lower the aircraft to the deck from the cable that caught it. Later the system would be used to assist in launching the aircraft as well.

Modifying an LST with this equipment eliminated the need for an aircraft carrier and, with the shallow draft of the LST, it was able to approach closer to shore than an aircraft carrier, which also gave the aircraft more time on station.¹⁰⁴ A total of seven LST’s were modified as aircraft carriers, only one of those (*LST-776*) was outfitted with the Brodie Device system.¹⁰⁵ Even though there was only one ship with a Brodie device

¹⁰²Raines, 221.

¹⁰³*Ibid.*, 285.

¹⁰⁴*Ibid.*, 267.

¹⁰⁵Friedman, 126.

installed, the Army incorporated the procedures into their first air-observation-post doctrine, Field Manual 6-150.¹⁰⁶

Early in the War, it became clear that there was a lack of repair facilities for ships, landing craft and vehicle maintenance in theater.¹⁰⁷ Twelve LSTs were converted into Auxiliary Repair Battle Damage ships (ARB). Their purpose was to provide temporary repairs to any damaged ship and to get them from the landing areas, which in most cases was remote, back to a suitable repair facility.¹⁰⁸ To address the issue for landing craft repair, several LSTs were converted into Auxiliary Repair Light (ARL) (Appendix B Figure 15). They were in convoy with the invasion forces to provide advance base repairs to the damaged landing craft. The bow ramp was removed, and the bow doors were sealed. A 50 ton derrick, two 10 ton booms, and winches were added to haul damaged landing craft aboard for repairs. The wheelhouse/chart room deck was expanded for additional workshops. The Tank Deck on these modified LSTs was converted into several different workshops and storerooms, to include electrical, machine, sheet metal, ship fitter, blacksmith, and pipe shops.¹⁰⁹

The LST was employed in both theaters as a hospital ship. Naval leaders quickly realized that one of the most effective employments for the tank deck was as a combat medical facility. They were fitted with adjustable tubular racks in order to carry 3-tier

¹⁰⁶Raines, 292.

¹⁰⁷Letter from Captain W. P. Carne, Royal Navy to Rear Admiral E. R. Cochrane USN concerning observations in landing operations in North Africa, 2 July 1943, National Archives Collection.

¹⁰⁸Ladd, 223.

¹⁰⁹Navy Department, *ONI 226-Allied Landing Craft and Ships*.

stretchers on either side of the Tank Deck; up to a total of 144 stretchers. They were utilized to transport wounded personnel to established land based hospitals or to hospital ships.¹¹⁰ For example; at Normandy on D Day, LSTs brought 41,035 wounded men across the English Channel to facilities in Great Britain. In 1945 a conversion was made to several LSTs into a hospital ships, thus re-designating them as LST(H) Landing Ship Tank Hospital.¹¹¹ At Iwo Jima, four LST(H)s were anchored 2,000 yards off shore in preparation for mass casualties to provide medical facilities once the beach heads were secure.¹¹²

In other operations in the Pacific Theater, the conversion of LSTs for casualty care was being done by ships' personnel. Watertight hatches were installed in the tank deck bulkhead on both the port and starboard sides giving access to the forward troop compartments. The troop spaces were converted into receiving rooms, sterilizer and scrub-up rooms and operating rooms. These alterations did not change the ships' capability to carry troops and equipment. Wounded troops were able to have lifesaving surgery done immediately instead of waiting to be transported to a hospital ship or shore facility. These ships were nicknamed "Surgical LSTs." They had limited capacity and were not ideal for long distance transportation of the wounded, they were adequate for

¹¹⁰A. K. Demetriades, M. C. Gavalas, and J. Ryan, "D-Day On Board A Tank Landing Ship: Meat, Cheese and Blood Transfusion," *Journal of the Royal Army Medical Corps* 154, no. 1 (April 2008): 51.

¹¹¹Friedman, 124.

¹¹²Ladd, 225.

longer distances if the seas were calm, however these ships were crucial to immediate casualty care because of the lack of Geneva-protected hospital ships in the region.¹¹³

Another testament to the versatility of the LSTs Tank Deck, in the European Theater, included several LSTs that had railroad tracks welded into the Tank Deck in order to deliver rolling stock to France (Appendix B Figure 16). Three lines of track were installed to accommodate a total of twelve freight cars. A three way switch was welded to the bow ramp in order to load and unload the cars. The ships moored to piers that had switching tracks installed on them to unload the rail cars.¹¹⁴ In May of 1945 20 LSTs were converted to Naval Ammunition Carriers for use in the Pacific.¹¹⁵ These LSTs were used for ammunition replenishment. Because of their size and capacity to carry over 1,000 tons of cargo, two or three LSTs were able to be moored alongside a battleship or heavy cruiser during amphibious operations.¹¹⁶

Another conversion of the LST in the Pacific Theater was the LST “Mother ship.” These ships supported the landing craft and their crews during extended landing operations. These were standard LST hull configurations, however that had two Quonset huts set up on the main deck. These accommodated up to forty officers. An additional

¹¹³Vice Admiral Daniel E. Barbey, U.S. Navy, Commander Amphibious Force, Southwest Pacific and Commander Seventh Amphibious Force, *Command History: Seventh Amphibious Force 10 January 1943--23 December 1945*.

¹¹⁴Gene Jaeger, *Flat Bottom Odyssey: From North Africa to D-day* (Henry, IL: Prairie Ocean Press, 2010), 124.

¹¹⁵Letter from Chief of Naval Personnel to Commander, Administrative Command, Amphibious Forces, Pacific Fleet, Subject of additional sailors for the conversion of the LST to an ammunition ship, 10 July 1945, National Archives collection.

¹¹⁶Friedman, 126.

two hundred personnel had berthing accommodations in the Tank Deck with cots. In addition to that, they had a bakery shop onboard, additional refrigeration units and four distilling units were added to provide fresh water to the ballast tanks that were converted to potable water tanks.¹¹⁷ The LST was also modified to serve as Motor Torpedo Boat Tenders (AGPs), Aircraft repair ships (ARV [A] and ARV [E]) as well as Salvage Tenders (ARST).¹¹⁸

The armament of the ship was also modified over time. The LSTs were originally outfitted with twelve 20-mm guns and seven single 40-mm guns. Three of the 40-mm guns were located on the bow in armored gun tubs, one directly on the bow and flanked on each side by two more. Four more were oriented on the aft of the ship, also placed in gun tubs. The 20-mms were distributed throughout the topside of the ship. In order to protect the ship from aircraft attack, the manual single 40-mm guns were replaced with electric driven twin 40-mm guns that were wired into a MK-51 gun director, giving the guns more accuracy.¹¹⁹ A 3-in/50 was also added aft on some LSTs. The crews of the ships also used whatever they had available to them at the time. In some instances the automatic weapons of the vehicles onboard or the cargo they may have been carrying such as 37-mm anti-aircraft guns.¹²⁰ The converted ARLs maintained a 3-in/50 aft, two quad 40-mm and eight 20-mm guns.¹²¹

¹¹⁷Palmar and Allen, 68.

¹¹⁸Friedman, 127.

¹¹⁹*The LST Employment* (MN-4302a), United States Navy Training Film, 1944.

¹²⁰Friedman, 123.

¹²¹Navy Department, *ONI 226-Allied Landing Craft and Ships*.

The basic design of the LST demonstrated its adaptability to the various requirements of the U.S. military during World War II. As operational experience was gained the ships were easily modified for such missions as the deploying LVTs without having to beach, launching and recovery light aircraft, as hospital ships, and as tenders. Because of this they were critical at the operational level. The LST made a tactical difference as well, creating the capability for rapid deployment of whatever cargo it carried, anywhere it was employed in the world. The LST served above and beyond its intended use of simply taking troops, tanks and cargo from a staging area to the beaches of the enemy.

CHAPTER 5

CONCLUSIONS

During the interwar period, the United States Navy and Marine Corps recognized the future threat of Japan in the Pacific. Through this recognition, they took the tentative steps to develop amphibious doctrine. However, due to fiscal restraints, they lacked the resources to adequately develop the landing craft and ships that were required to successfully support that doctrine. It wasn't until the catalyst of the British requesting assistance in designing and building an amphibious landing ship, that the solution showed itself in the LST. Even though there was a focus on aircraft carriers, battleships, submarines and destroyers at the time, the U.S. accepted that there was a need for a ship that possessed the capabilities of the LST. There is no doubt that the LST was the ideal platform to conduct amphibious operations successfully in WWII and its design concepts can still be valuable in a modern amphibious warfare environment.

The LST was easily adapted to the proliferation of needs that the different theaters of operation brought. This was because the LST was so simple. It was a deviation from the devotion to a high technology military solutions that are common today. The published doctrine of the time was not written with the LST in mind, the ship was “shoehorned” in to an already established method of conducting amphibious warfare. However, the LST transformed the way amphibious warfare was conducted, especially at the operational level. The LST was an excellent example of a simple innovation used to solve a complex problem. The adaptability that the LST possessed was far beyond what its original design intended it for. The technology that was used to develop the LST already existed in other platforms, such as the use of ballast tanks to adjust the draft of

the ship for ocean voyage or beaching operations. This was due in part to the fact that the designer, John Niedermair, designed submarines and to him the concept was obvious. Ballast systems were not used in surface vessels prior to the LST. It was serendipitous that he was assigned to be the designer of this unique ship. Without his knowledge of ballast systems and their utilization in ship design, the LST would not have possessed the capability for open ocean transit. Thus it would have been ineffective for the majority of amphibious operations that it would perform, mainly in the Pacific. This simple concept continues to be a constant in amphibious ship design.

The LST had the capability to load combat cargo in a staging area far from the objective, conduct an open ocean voyage, over literally thousands of miles, and deliver that cargo directly to the beach quickly and efficiently. Because of this, it created a fast paced operational tempo that the United States had not foreseen and the Japanese were not prepared for. Without the LST, the Allied Forces would not have possessed the means to conduct large scale amphibious operations in the Pacific or the Atlantic theaters of operation as rapidly as they did. This was also due in part to the United States' ability to produce large numbers of LSTs to be deployed around the world in a short period of time.

The analysis here suggests that building the LST rapidly and in such large quantities, proved how quickly the American industrial infrastructure could be adapted to support the war effort. Between 1942 and 1945 the U.S. built 1,051 LSTs. The location of most of the ship yards were on the East and West coast and they were largely used for constructing large, deep-draft vessels. Because of this, new ship yards were established along inland waterways throughout the Midwestern United States to support the sudden

high demand for the LST. Heavy-industry plants such as steel fabrication yards and bridge companies were even converted for building LSTs. The success of these newly established shipyards astonished the well-established shipyards of the coastal areas. Even though the British proposed the concept of the LST to the U.S., only 113 were delivered to and operated by the Royal Navy.

The LST, small amphibious ship that it was, had an immense global strategic impact. The simple fact that the D-day invasion of Normandy was planned based on being able to obtain the adequate number of LSTs for the operation, demonstrates its importance. Prime Minister Winston Churchill was quoted as saying “The destinies of two great empires . . . seemed to be tied up in some god-damned things called LSTs.”¹²² Once its utility was realized, the LST was quickly recognized as an operational asset to any amphibious operation, be it assaulting a beach or in a logistical support role.

In answer to the primary thesis question, published amphibious doctrine changed very little throughout the war. By mid-1943 all services were using the same amphibious doctrine publications. Even though there had been revisions, the tenants of the original Marine Corps *Tentative Manual for Landing Operations* remained operative throughout the war. However, the LST did change how amphibious warfare was conducted on a tactical level. The fact that troops and equipment were no longer being loaded onto landing craft from transports while anchored at sea reflected this truth. The increased capacity of the LST to carry large numbers of tanks and tracked amphibious vehicles, along with its ability to beach, changed how combat forces were deployed to hostile

¹²²Quoted in Eric Larrabee, *Commander In Chief Franklin Delano Roosevelt, His Lieutenants and Their War* (Annapolis, MD: Naval Institute Press, 1987), 444.

shores. The LST impacted the operational level of war, in that it was a factor in the decision making process for campaigns made at the various strategic planning conferences, in both theaters of operation, by the Allied Combined Chiefs of Staff (CCS). The LST could be combat loaded at a staging area and transit the open ocean thousands of miles and deliver its cargo directly to the beach. This was operational maneuver from the sea (OMFTS), WW II-style. OMFTS, a 1990s Marine Corps concept was described as, “the maneuver of naval forces at the operational level, a bold bid for victory that aims at exploiting a significant enemy weakness in order to deal a decisive blow.”¹²³ The LST also brought the capability of a retrograde of large numbers of troops and equipment from the beach if necessary. This proved invaluable on many occasions, especially when the LST acted as an emergency hospital to remove wounded from the combat zone quickly.

In conclusion, there is no doubt that the LST performed a vital service to the U.S. and its Allies during WWII and it changed how the U.S. military conducted amphibious operations on a tactical and operational level. Planning decisions were made based on the operational flexibility the LST gave commanders that had strategic consequences beyond the ramp up in operations tempo. It unhinged Japanese efforts to defend an interior line, somewhat like trains had done on land. Although, unlike trains, the LST could deliver its cargo directly to the beach and into combat. The LST did not have the glamor or glitz of the battleships or aircraft carriers, but it was as invaluable to the Allied offensive in every theater of operation. It was truly the work horse of the Fleet.

¹²³ Concepts Division, Marine Corps Combat Development Command, *Operational Maneuver from the Sea* (Washington, DC: Government Printing Office, 1997), 10.

The LST changed the way in which the importance of amphibious warfare was viewed by the military. It brought a versatile capability to amphibious warfare that had not been seen before. As a testament to their durability of concept and utility, several countries currently operate LSTs based off the design of the WWII variant, such as India.¹²⁴ It is also a capability that the U.S. no longer possesses in our modern military force. The last LST in the U.S. Navy, *USS Frederick (LST-1184)*, was decommissioned in October of 2002.¹²⁵ The U.S. lacks a simple shallow draft landing ship that can conduct open ocean transits, be beached or operate without the use of prepared ports, with the ability to unload large amounts of military equipment or cargo in a short period of time.

With the publication of the Cooperative Strategy for 21st Century Seapower, and its stated commitment to humanitarian operations, the United States has not hesitated to commit major naval capabilities to Humanitarian Assistance and Disaster Response (HADR).¹²⁶ This has been seen recently in November of 2013 with the Philippine Islands being hit by Super Typhoon Haiyan and the response the U.S. provided.¹²⁷ Considering

¹²⁴James Goldrick, "India's Expeditionary Journey," *Proceedings Magazine* 139 (March 2013), <http://www.usni.org/magazines/proceedings/2013-03/indias-expeditionary-journey> (accessed 27 November 2013).

¹²⁵Jim Williams, "USS Frederick Decommissioned: Navy's Last Tank Landing Ship Leaves the Fleet," *Navy News*, 16 October 2002, http://www.navy.mil/submit/display.asp?story_id=3969 (accessed 29 November 2013).

¹²⁶Gary Roughead, James Conway, and Thad Allen, *A Cooperative Strategy for 21st Century Seapower* (Washington, DC: Government Printing Office, October 2007), 20.

¹²⁷Commander, U.S. 7th Fleet Public Affairs, "31st MEU Elements Arrive Near Tacloban, Philippines," http://www.navy.mil/submit/display.asp?story_id=77808 (accessed 22 November 2013).

the Navy and Marine Corps increased role in HADR, where they would be expected to support operations in locations where port facilities would either be damaged or non-existent, an LST-like capability will prove invaluable. A vessel like an LST also brings the capacity to deliver a mass quantity of heavy equipment, such as Abrahams tanks, directly to the beach at one time; something that the current Landing Craft Air Cushioned (LCAC) is not capable of doing.¹²⁸ With the budget restraints and austerity that the military can expect to see in the future, perhaps the U.S. should look to the simple solution for the answer to future amphibious ships. As has been seen through the history and research provided, the LST was an affective and versatile platform that proved to be successful, because of its simplicity that fulfilled a critical role in amphibious warfare.

Recommendations for Further Research

My recommendation for further research, based off of the findings that this thesis highlighted, is a review of U.S. amphibious doctrine after 1945 to determine if the lessons learned from WWII and the employment of the LST were incorporated. This could similarly include the analysis determining the LST's impact on war fighting capabilities in conflicts after WWII, such as Korea and Vietnam. Another aspect to research further is a comparative historical study of how U.S. allies, mainly Great Britain, employed their LSTs after WWII and how many countries still operate versions of the LST.

¹²⁸Susan Altenburger, Michael Bosworth, and Michael Jung, "Landing Craft for the 21st Century," *Proceedings Magazine* 139 (July 2013), <http://www.usni.org/magazines/proceedings/2013-07/landing-craft-21st-century> (accessed 22 November 2013).

Since the LST was such an innovative concept and design for a ship at the time it was developed, I recommend further research and analysis determining if the design and employment of the WWII LST had any influence on developing the later Newport Class LST. Since the U.S. Navy no longer has LSTs, I also recommend an analysis of a modern ship design that has the capability of beaching and retracting like the LST. This would include an analysis of capabilities, if any, that a new LST designed as simply as the WWII variant would bring to the Navy and Marine Corps Team in a high tech military environment.

APPENDIX A

AMPHIBIOUS WARFARE IN THE INTERWAR PERIOD

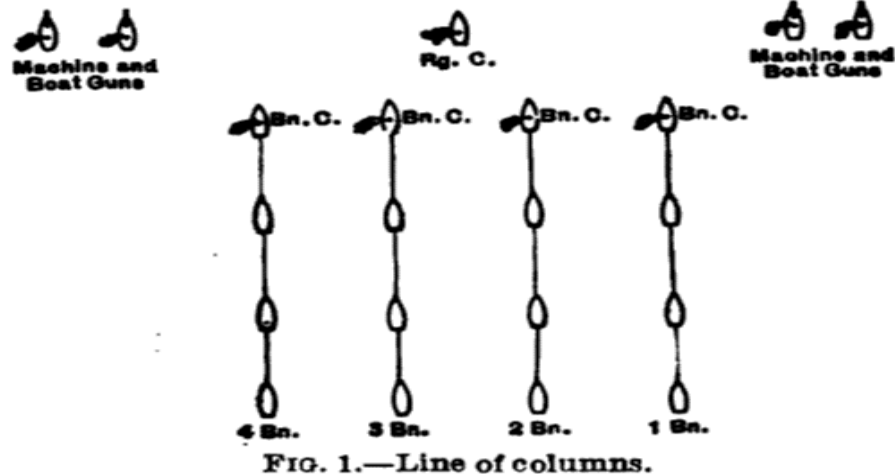


Figure 1. Diagram on how to Form Boats to be Towed to Shore for Landings

Source: U.S. Navy Department, *Landing Force Manual, United States Navy, 1927* (Washington, DC: Government Printing Office, 1921).



Figure 2. The First Dedicated USM Landing Craft, the "Beetle" Boat

Source: David N. Buckner, *A Brief History of the 10th Marines* (Washington, DC: Government Printing Office, 1981), USMC picture 515227.

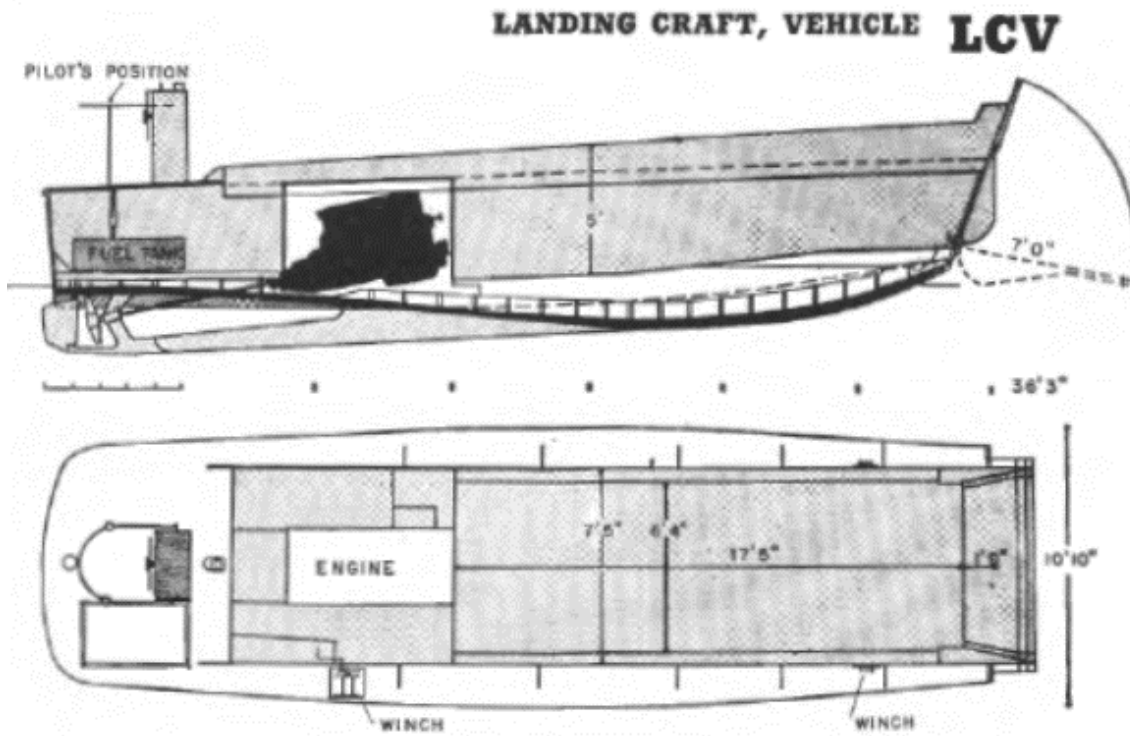


Figure 3. The Eureka

Source: Navy Department. *ONI 226-Allied Landing Craft and Ships* (Washington, DC: Navy Department, 1944).

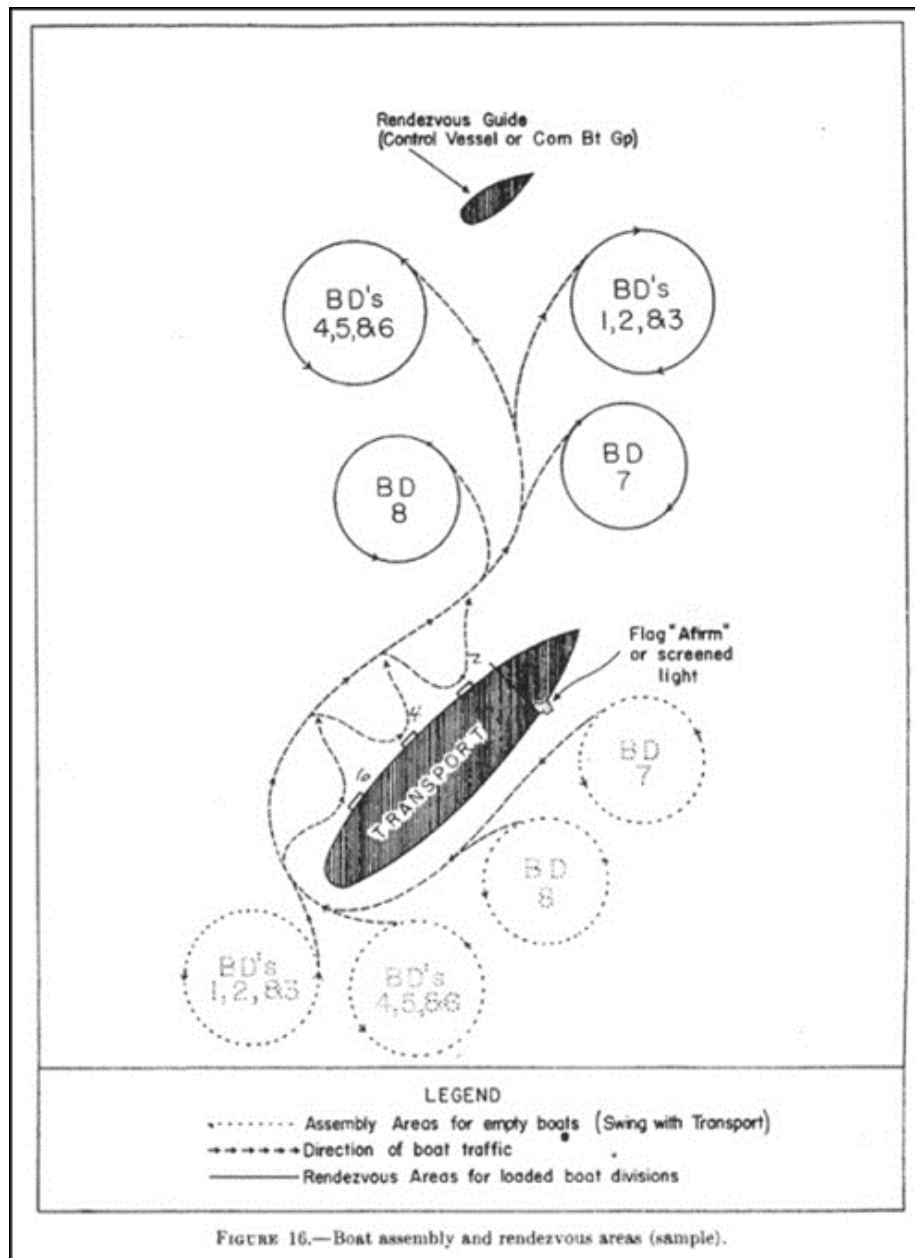


Figure 4. Troop Disembarkment from Anchored Ship

Source: War Department, War Department Field Manual 31-5, *Landing Operations on Hostile Shores* (Washington, DC: War Department, 1944). This diagram is an example of how troops would disembark the transport ship at anchor, then continue to shore.

APPENDIX B

LST MODIFICATIONS

Photo # NH 99567-A USS LST-481 at the Mare Island Navy Yard, 20 May 1943



Figure 5. USS LST-481

Source: Naval History and Heritage Command, “USS LST-481,” U.S. Navy, <http://www.history.navy.mil/photos/sh-usn/usnsh-1/lst481.htm> (accessed 20 November 2013). Note ventilation stacks on the main deck.



Figure 6. Bow Ramp and Bow Doors

Source: Photo by author.

Photo # 80-G-252797 USS LST-325 & LST-388 unload at low tide during Normandy invasion, 12 June 1944



Figure 7. USS LST-325 and LST-388

Source: Naval History and Heritage Command, “USS LST-325 and LST-388,” U.S. Navy, <http://www.history.navy.mil/photos/sh-usn/usnsh-l/lst481.htm> (accessed 20 November 2013). Note the Skegs, a sternward extension of the keel, in this case used to support the rudder and protect the propeller.

Photo # 80-G-247120 USS LST-1 and LST-292 "high and dry" on a Brittany beach, Sept. 1944



Figure 8. USS LST-1 and LST-292

Source: Naval History and Heritage Command, "USS LST-1 and LST-292," U.S. Navy, <http://www.history.navy.mil/photos/sh-usn/usnsh-l/lst481.htm> (accessed 20 November 2013). When an LST was "High and Dry," it used its ballast system for engine cooling.

Photo # USA C-175 USS LST-1 landing troops on an Italian beach

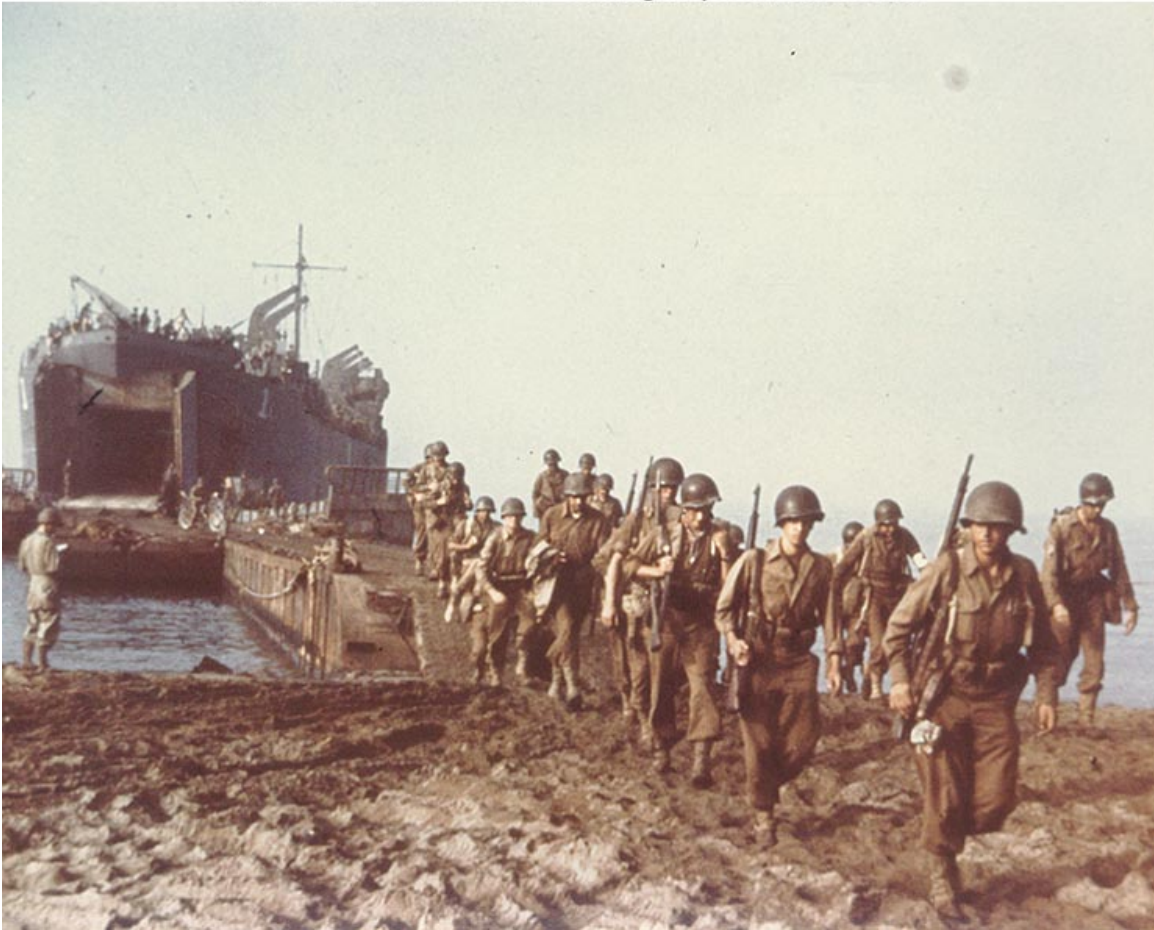


Figure 9. Pontoons Being Used for the Invasion of Italy

Source: Naval History and Heritage Command, "USS LST-1," U.S. Navy, <http://www.history.navy.mil/photos/sh-usn/usnsh-1/lst481.htm> (accessed 20 November 2013).



Photo # 80-G-74826 USS LST-4 off Gela, Sicily, 10 July 1943

Figure 10. USS LST-4

Source: Naval History and Heritage Command, “USS LST-4,” U.S. Navy, <http://www.history.navy.mil/photos/sh-usn/usnsh-l/lst481.htm> (accessed 20 November 2013). Note the four extra davits added to this LST for the invasion of Sicily.

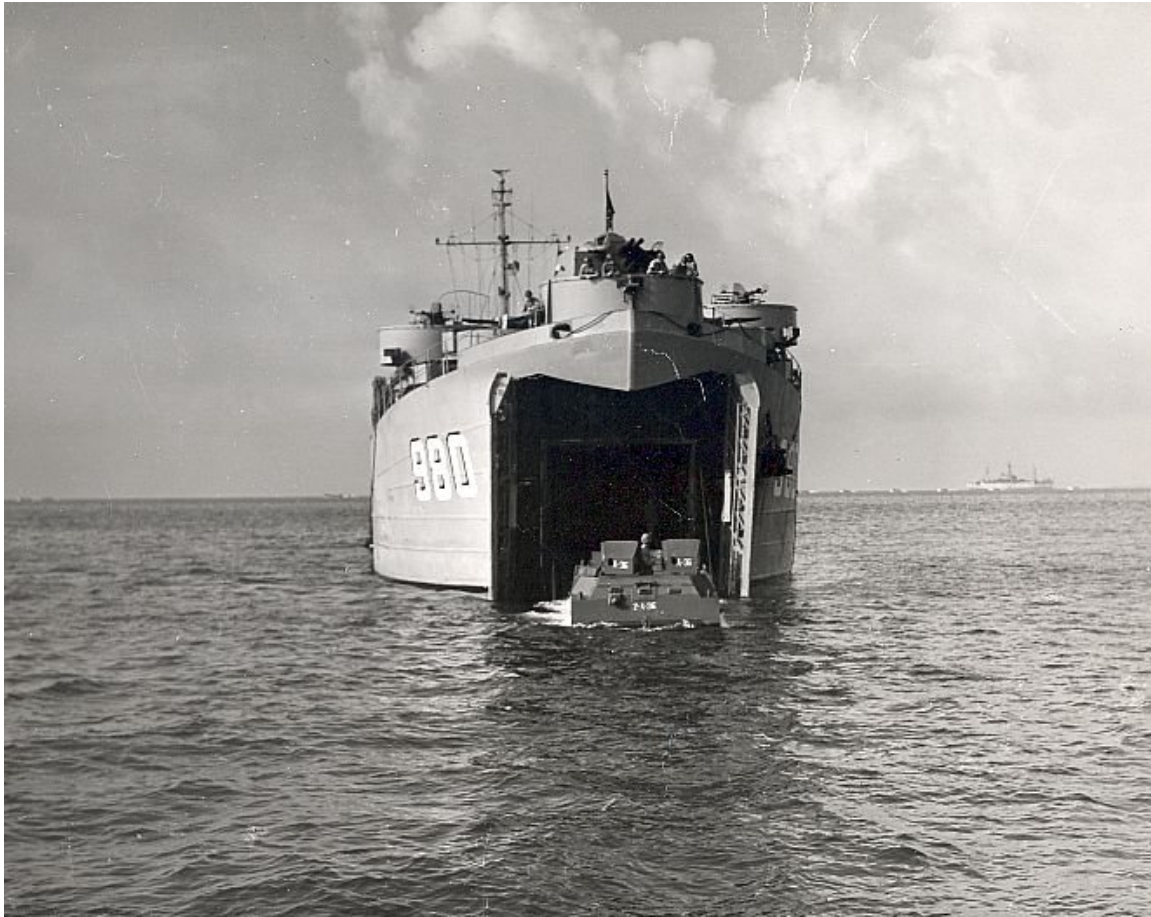


Figure 11. LST 980 Launches an LVT from the Bow doors while at Sea

Source: NavSource Naval History, “LST-980,” <http://www.navsource.org/archives/10/16/160980.htm> (accessed 20 November 2013).



Figure 12. Australians Departing LST-937

Source: NavSource Naval History, “Australians Departing LST-937,” <http://www.navsource.org/archives/10/16/160980.htm> (accessed 20 November 2013). The Main Deck ramp lowered for direct access to the Bow ramp. This made unloading of vehicles from the Main Deck more efficient than the original elevators that were installed.



Figure 13. Army Piper L-4 Cub artillery observation plane takes off from an LST

Source: Naval History and Heritage Command, “Army Piper L-4 Cub Artillery Observation Plan Takes Off from an LST,” U.S. Navy, <http://www.history.navy.mil/photos/sh-usn/usnsh-1/lst481.htm> (accessed 20 November 2013). Runways were built on several LSTs, for launching light spotter aircraft. Here an Army Piper L-4 Cub artillery observation plane takes off from an LST at Anzio, 1944. Note the aircraft stowage on the port and starboard side.



Figure 14. LST with Brodie System

Source: NavSource Naval History, “LST with Brodie System,” <http://www.navsource.org/archives/10/16/160980.htm> (accessed 20 November 2013). The “Brodie” system that was installed for recovering and launching light spotter aircraft. Note the booms with wires spanned between them, with aircraft, on the forecastle and the port quarter of the ship.



Figure 15. An LST Converted into an Auxiliary Repair Light (ARL)

Source: NavSource Naval History, “LST Converted into an ARL,” <http://www.navsource.org/archives/10/16/160980.htm> (accessed 20 November 2013). Note the added booms and workshops on the Main Deck.



Figure 16. LST-21 Off-loading Railroad Cars

Source: United States Coast Guard Historian's Office, "LST-21," United States Coast Guard, USCG Photo No. 4387, http://www.uscg.mil/history/webcutters/img/LST21_RR_1.jpg (accessed 20 November 2013).

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